SPACER FOR INSULATED WINDOWS HAVING A LENGTHENED THERMAL PATH

CONTINUING INFORMATION

This is a continuation-in-part application of pending patent application Serial No. 10/091,704, entitled "Spacer for Insulated Windows having a Lengthened Thermal Path", which was filed March 5, 2002 as a continuation application of issued patent No. 6,351,923, which was filed July 21, 1999 as a continuation-in-part application of issued patent No. 6,131,364, which was filed on December 29, 1998 as a continuation-in-part of patent application Serial No. 08/898,705, which was abandoned on July 22, 1997.

BACKGROUND OF THE INVENTION

a. Field of the Invention

The present invention relates to spacer frame bars which are used to maintain separation between glass panes in insulated glass windows and other panels and, more particularly, to a spacer frame bar having folded or corrugated sides so as to permit the bar to be bent at the corners of the spacer frame without coverstressing the lower web of the bar.

b. Related Art

It is well known in the art to provide a window with more than one pane of glass separated by an airspace. Such windows are known as insulating windows or insulated glass panels, by virtue of the fact that the air and/or other gasses (argon, helium, nitrogen, etc.) trapped within the space between the glass panes serves as an insulator to reduce heat flow through the window.

Typically, the glass panes are separated by a spacer frame which lies between the glass panes and extends around their perimeter. The spacer frame is typically constructed

of sections of tubular material, also known as spacer frame bars, which are usually made of a metal such as aluminum alloy, steel or stainless steel. In addition to being commercially economical, these materials have the strength and rigidity which are required in order for the spacer frame serve its structural functions. Also, aluminum and steel exhibit good corrosion resistance and are stable over a wide range of temperatures, and the structural integrity of these materials is not adversely affected by long-term exposure to sunlight.

The use of aluminum, steel or other metals in a spacer frame, however, is not without its problems. A significant heat transfer problem may arise because an aluminum or metal spacer is a much better heat conductor than the surrounding airspace. Because the spacer and glass panes are contiguous, the spacer itself acts as a conduit for energy transfer between inside and outside panes of glass. Thus, significant energy loss may result because of the spacer's physical contact with the glass panes.

Moreover, heat transfer through the spacer may cause the edge or other area of the window which is in contact with the spacer to be at a significantly higher or lower temperature than the rest of the pane. In particular, where outside temperatures are cold, this may cause the edges of the window to be relatively cool around the interior pane (i.e., cooler than the interior of the building), resulting in serious condensation problems.

One partial solution to heat transfer through the spacer is provided by U.S. patent No. 5,568,714 to Peterson. The invention of Peterson provides an elongate tubular spacer with an integral thermal break that reduces energy flow between glass panes. Although the thermal break impedes heat transfer through the spacer, heat transfer impedance can still be an issue because the metal on either side of the thermal break still rapidly conducts thermal energy.

Another partial solution is provided by U.S. Patent No. 5,377,473 to Narayan et al. The invention of Narayan provides a spacer having a lower web which is generally W-shaped in cross-section, and an upper web which is pierced by a series of slots which are intended to eliminate straightÄline thermal paths across the web and also to allow fluid contact between the air in the interpane space and a desiccant material inside the spacer. Unfortunately, the slots allow the desiccant material (typically, a silica gel or other material which is in granular form so as to maximize surface area) to escape from

the spacer and into the interpane space, where it tends to foul the inside surfaces of the panes.

An additional problem of conventional spacer bar tubing is its inability to form sharp (e.g., 90°) bends, specifically, the bends at the corners of a window spacer frame. As the tubing is bent to form a corner, the outside bend of the tubing is forced to stretch, and the sidewalls of the tubing are also both stretched and compressed. This combination of forces frequently causes the outside (lower) flange of the tubing to snap under tension, and frequently cause the sidewalls to break as well, so that the tubing and frame are ruined. Moreover, even if the tubing does not suffer outright breakage, the stretching forces cause the outside web to separate along any seams or joints formed therein, for example, at the welded or crimped seam formed when manufacturing of the tubing. This problem is severe enough with tubing having an ordinary rectangular cross section, and would be even more pronounced in the case of tubing having a vertically-folded lower web, such as that which is shown in the Narayan reference.

Because of these difficulties, angled connector pieces, known as "corner connectors," have been developed which are inserted into ends of straight sections of tube at the corners of the spacer frame. Although effective in their own right, the use of corner connectors obviously means that additional pieces (the connectors) must be used in the assembly and it also means that sections of tubing must be cut to form the sides of the spacer frame, which adds significantly to the time and expense of the assembly process. In some instances the connectors also have a tendency to inadvertently slide out of the tubing or form a bad connection, again slowing and adding waste to the process.

Accordingly, there exists a need for an improved metal spacer bar which defines elongate thermal conductive paths between glass panes. Furthermore, there exists a need for such an improved spacer bar which can be bent at a sharp angle to form corners of a spacer frame without breaking or otherwise stressing the outer web thereof. Still further, there exists a need for such an improved spacer bar which is simple and economical to manufacture.

SUMMARY OF THE INVENTION

The present invention has solved the problems cited above. Broadly, this is a spacer frame bar comprising an elongate tubular spacer member having first and second side webs for engaging first and second glass panes in spaced relationship, and upper and lower webs spanning from the first side web to the second side web, each side web being formed of a yieldable material and comprising at least one corrugation that defines a vertically spaced gap, so that in response to bending of the spacer frame bar about the upper web the gaps of the corrugations collapse so as to reduce a height of the spacer bar and thereby reduce the distance by which the lower web is stretched at an outside radius of the bend.

Each side web may comprise an upper portion that forms a contact area for engaging a pane of glass and a lower portion having the said at least one corrugation formed therein. The lower portion of each side web may comprise a plurality of the corrugations.

Each of the corrugations may comprise upper and lower wall portions that are spaced apart by said gaps and that move into engagement so as limit collapse of said side webs as said spacer frame bar is bent. The wall portions of said corrugation extend generally parallel to one another and generally parallel to the upper and lower webs of the bar.

The upper and lower webs and said first and second side webs may define a hollow interior of the bar, and the wall portions of the corrugations may limit collapse of the side webs to a predetermined amount such that a passage remains open through the interior of said bar at the bend.

These and other features and advantages of the present invention will be apparent from a reading of the following detailed description with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of the invention will become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a perspective view of an insulated glass panel constructed with spacer bar tubing in accordance with the present invention;

FIG. 2 is a cross-sectional, perspective view of a portion of the insulated glass panel of FIG. 1, showing a first embodiment of spacer frame bar in accordance with the present invention positioned between two glass panes, showing the corrugated and slitted upper web thereof;

FIG.3 is a side, elevational view of the spacer frame tubing of FIG. 2, showing the manner in which the holes in the side walls of the tubing enable the side walls to collapse so as to avoid overstressing the outer web of the tubing as it is bent to form a sharp angled corner;

FIG. 4 is a front, elevational view of a spacer frame having corners formed by bending the spacer frame tubing as shown in FIG. 3;

FIG. 5 is a an end, cross sectional view of a spacer frame tubing of FIG. 2, showing the profile thereof in greater detail;

FIG. 6 is an end, cross sectional view, similar to FIG. 5, of another embodiment of spacer frame tubing in accordance with the present invention, again showing the corrugated profiles of the side walls thereof;

FIG. 7 is an end, cross sectional view, similar to FIGS. 5-6, of another embodiment of spacer bar tubing in accordance with the present invention, each side wall thereof having a single hole corrugation formed therein;

FIG. 8 is a perspective, cross sectional view, similar to FIG. 2, showing another embodiment of spacer bar tubing in accordance with the present invention, this having holes or corrugations in the upper web as well as the side walls thereof;

FIG. 9 is a perspective, cross sectional view, similar to FIG. 8, of another embodiment of spacer bar tubing in accordance with the present invention, this having a

generally flat, slitted top web in place of the corrugated web which is shown in FIG. 8; and

FIG. 10 is an enlarged, cross-sectional view of the joint formed between the upper web and lower channel in another embodiment of the two-piece spacer construction, in which the edge of the upper web has a small return bend for forming a locking interfit with a corresponding lip along the edge of the channel member.

FIG. 11 is an elevational view of a portion of a window spacer frame constructed using the spacer bar of the present invention, shown in the manner which the tubular bar is bent to form a 90° corner;

FIG.12 is a first simplified cross sectional view of the bar forming the spacer frame, taken along line 12-12 in FIG. 11, showing the configuration of the spacer bar in the straight sections of the frame; and

FIG. 13 is second simplified cross sectional view of the bar of the spacer frame, taken along line 13-13 in FIG.11, showing the manner in which the corrugations collapse when the spacer bar is bent so as to reduce stretching and damage to the structure thereof.

DETAILED DESCRIPTION

a. Spacer Structure

An insulated glass panel 10 in accordance with the present invention is illustrated in FIG. 1. As can be seen, panel 10 includes an essentially rectangular spacer frame 12 sandwiched between first and second panes of glass 14a, 14b, thereby defining a hermetic airspace 16 within the space bounded by the panes and frame. The frame 12 extends completely around the outer periphery of the insulated glass panel 10, adjacent the peripheral edges of the glass panes 14. The frame is formed by a spacer frame bar 18, referred to herein from time to time as simply the "spacer" or "spacer tubing".

For ease of understanding, the terms "upward", "upper", "top" and so on will refer in this description and the appended claims to that side of the spacer which faces towards the interpane space (i.e., towards the space between the two panes; conversely, the terms "downward", "lower", "bottom" and the like will refer to the side of the spacer which faces in the opposite direction (i.e., outwardly from the interpane space), and the terms "side", "lateral", and the like will refer to the sides of the spacer which face towards the panes. It will be understood, of course, that the actual physical orientation of the spacer will depend on its location within the window or other panel. Furthermore, the term "window", as used in this description and the appended claims, means all panels constructed of glass or similar panes, whether used for viewing, admission of light, or other purposes.

FIG. 2 shows the spacer tubing 18 of which frame 12 is constructed. As can be seen, the spacer tubing is generally rectangular in cross-section, having generally parallel upper and lower webs 30, 32, and generally parallel side webs 34, 36. The four webs define a hollow interior 40, which typically contains a mass of desiccant material 42, such as silica gel, usually in particulate form.

In the embodiment which is illustrated in FIG. 2, the spacer bar is formed by joining first and second halves 44, 46, each of which has a generally "C" shaped cross-sectional profile. The first and second halves are preferably each roll formed from a continuous piece of high strength material, such as aluminum alloy or steel, although

other materials, such as glass or composite materials, are within the scope of the invention. Similarly, although the spacer bar which is shown in FIG. 2 is constructed from inner and outer halves, other forms of construction, such as the two-piece "clip-together" construction described below or unibody construction, are also within the scope of the present invention.

The two halves 44, 46 may be joined in any suitable manner. In the embodiment which is illustrated, the longitudinal edges of the halves are periodically and transversely slit to define a series of short, transverse tabs which are alternately crimped. The crimped tabs are interleaved in alternating fashion to form the connection between the edges of the halves: As is shown, a first elongate seam 50 is thus formed along the upper web 30 of the spacer by the overlapping intersection of the first and second halves, and a second seam 52 is similarly formed along the lower web 32. The seams each preferably include an insulating strip 54, which is installed between the interleaved tabs to form an integral thermal break between the two halves. The insulating strip 54 is suitably formed of a non-metallic, low heat-conductive material, such as plastic or rubber, for example, and is preferably interwoven into the seams in the manner disclosed in U.S. Patent No. 5,568,714 to Peterson, the disclosure of which is hereby incorporated by reference herein.

The first and second side webs of the spacer bar preferably contact the glass panes 14a, 14b, along integrally molded upper and lower contact ridges 56a, 56b and 58a, 58b, such that the contact area between the spacer bar and the glass panes is essentially limited to two sets of lines. The upper contact lines are formed substantially near the corners between the top and side webs of the bar, while the lower contact lines are formed a spaced distance below the upper contact lines, preferably substantially near the midpoints of the side webs 34, 36. The upper and lower contact lines protrude beyond the general plane of their respective side webs, with curved recesses 60a, 60b being formed between each pair of lines. While thus limiting contact between the bar and panes to two sets of contact lines is generally preferred, it will be understood that other configurations, such as flat side walls which contact the glass panes, are also in the scope of the present invention.

As is shown in FIG. 2, a sealant 64, preferably an elastomer or mastic-like material, extends about the outer periphery of the insulated glass panel 10 and is formed

into the recesses of the first and second halves of the spacer, as well as into other spaces between the side webs 34, 36, and the panes 14a, 14b. The sealant 63 thus assures that the panes are hermetically bonded to the frame 12.

In the embodiment of the invention which is illustrated in FIG. 2, the lower halves of the side webs 34 and 36 are provided with horizontal folds 66. The folds are formed below the lower contact lines 58a, 58b, such that these define parallel and alternating indentations and protrusions which extend substantially normal to the plane of the glass. The folds lengthen the thermal migration path through the bottom and sides of the spacer, by providing additional material through which heat must travel before reaching the opposing pane. The folds in the side webs do not contact the panes, and therefore define voids which are filled with the sealant material. While providing folds in the side webs is thus generally preferred, it will be understood that side webs which are devoid folds are also within the scope of the invention.

So as to further increase the length of the conductive path across the bottom of the spacer bar, the lower seam 52 can also be bent upwardly as shown in FIG. 2, so that the interleaved tabs assume something of an inverted "V" configuration. Additionally, this configuration reinforces the engagement of the tabs, so as to form a very strong seam which resists separation of the two halves of the assembly.

b. Upper Web

With further reference to FIG. 2, it will be seen that the upper web 30 of the spacer bar, rather than being flat as in conventional forms of construction, is provided with a plurality of longitudinal, substantially parallel corrugations 70. These follow a somewhat sinusoidal path about the generally horizontal plane of the upper web, each corrugation defining a ridge portion 72 and a channel portion 74.

In the embodiment which is illustrated in FIG. 2, in which the first and second halves of the spacer are joined by longitudinal center seams, the corrugations are arranged into first and second parallel sets on either side of the top seam. The outermost ridges 76a, 76b in each set may conveniently be formed as continuations of the bends which form the upper contact lines 56a, 56b, with the a material being bent back on itself so as to extend inwardly and downwardly towards the adjacent channel; the innermost

ridges 78a, 78b, in turn, flank the center seam 50 and flatten out along their inner edges to form the interlocking tabs. In other embodiments, of course, the seam may have a different form or the corrugations may be continuous across the entire upper web of the spacer.

Furthermore, each of the corrugations 70 preferably includes a series of longitudinally-oriented, spaced apart slits 80. As can be seen in FIG. 3, there are preferably at least two rows 82a, 82b of slits in each corrugation, on opposite sides of each channel. A particular advantage of the corrugated upper web is that the corrugations increase the number of slits which can be formed in the space between the two glass panes; for example, a section of flat, planar web might be able to accommodate only one row of slits in the same space where the corrugated web is able to accommodate two such rows.

As can be seen with reference to FIGS. 2-3, each of the slits 80 forms a thermal break, i.e., the longitudinal edges of the slit are separated by an air gap which prevents direct communication of thermal energy across the slit. Moreover, the slits are preferable arranged so as to be staggered from one row to the next, such that the slits in one row alternate and overlap in spaced relationship the slits in the next row, thereby eliminating any straight-line conductive path in the transverse direction.

The slits 80 therefore cooperate with corrugations 70 to greatly increase the length of the conductive path across the upper web of the spacer. As can be seen in FIG. 3, the corrugations force the energy to follow a path which travels up and down in the vertical plane, while at the same time the staggered slits force the energy to travel back and forth in the horizontal plane. As a result, thermal energy passing from one glass pane to another follows a tortured, circuitous path as indicated by arrows 93, through a distance which is much longer than the straight-line distance from one glass pane to the other.

In addition to providing thermal breaks, the slits also serve as ventilation apertures which establish fluid communication between the inter-pane airspace 16 and the interior of the spacer. This allows the desiccant material 42 (e.g., silica gel) in the spacer to dehumidify the air/gas which is trapped in the airspace during assembly of the window, thereby minimizing the possibility of condensation forming inside the window. As is well known in the art, air is constantly circulated within the window by changes in

barometric pressure, which cause the glass panes to act like diaphragms which pump air in and out of the airspace 16.

In order to permit the air pass in and out of the spacer, but at the same time prevent the desiccant material from escaping, slits 80 are preferably formed not by punching or piercing clear through the upper web of the spacer, but instead by shearing or splitting the material along the edges 84, 86 of the slits and moving this apart so as to create an air gap which is wide enough to interrupt conduction of thermal energy, but not so large as to allow granules of desiccant to pass therethrough. The slits can be formed in this manner using a rotating cutter reel, which allows the slits to be formed continuously during roll forming of the spacer, rather than having to stop or otherwise hold the material stationary for punching or stamping.

When the slits are formed in this manner, the metal also breaks or "tears" back at the ends of the slits, forming first and second transverse edges 88a, 88b (see FIG. 3). The result is essentially a shallowly bent tab portion 90, bordered by thermal breaks along three sides. The "tear back" edges 88a, 88b along the sides of the tabs extend laterally towards the next row of slits, which further increases the length of the conductivity path by not allowing the heat to travel in a direct, diagonal line from the end of one slit to the next.

While, as has been described above, the corrugated configuration of the upper web provides a greatly lengthened thermal path, it does not accomplish this at the expense of added thermal gain when exposed to solar radiation. As is seen in FIG. 4, solar radiation passing through the outer glass pane 14a, as indicated by arrows 98, strikes only the tops or "crowns" 100 of the ridge portions, the major portion of each corrugation being shadowed by its neighbors. In other words, only the crowns 100 are exposed to the radiation, and these represent only a very small fraction of the total surface area of the web 30. Moreover, because the surfaces of the crowns 100 are curved (owing to the curvature of the bends in the metal), these will have a tendency to deflect and scatter solar radiation rather than absorb it, even when the sun is at its highest elevation relative to the spacer.

The advantages provided by the corrugations in the upper web pertain regardless of whether the web also includes the slits 80. It will therefore be understood that, while a

preferred form and arrangement of slitted web has been described above, spacers having webs with other forms of slits or no slits at all are also within the scope of the present invention. It will also be understood that while the vertically aligned, evenly spaced corrugations which are shown in the figures have numerous advantages, including manufacturing economy, ease of installation and aesthetics, for example, in other embodiments the corrugations may be angled in one direction or another, may have varied spacings or heights, and so on. Moreover, in some embodiments the corrugations may be formed by means other than by the roll-forming or bending of sheet metal, as by casting, cutting or machining, for example.

c. Insulating Strips

As is shown in FIG. 5, the channel portions 74 of the corrugations can be filled with an insulating material 110, so as to further reduce thermal gain and heat migration across the upper web of the spacer. In the embodiment which is illustrated in FIG. 5, the insulating material is formed into a plurality of individual strips 112 which are installed in the channels by suitable means, such as by pressing or by extruding the material directly into the channels, for example.

Since, as can be seen in FIG. 6, the strips of insulating material leave only the very tops of the crowns 100 exposed, the potential for thermal gain from absorption of solar radiation is greatly minimized. Moreover, to further reduce thermal gain, the crowns (or the entire top of the upper web) can be painted white, since this color generally has the lowest thermal absorption rate, and the insulating material itself can also be painted or formed in a white color if desired.

The geometry of the channels is preferably configured so as to grip the insulating material and retain it therein, since the different thermal expansion rates of the insulating material and metal web will otherwise tend to cause the former to buckle or "pop" out of the channels. For example, in the embodiment which is shown in FIG. 5 the tab portions 90 of the slits 80 are bent inwardly and upwardly, so that their edges protrude into the channels and thereby engage the lower edges of the strips 112.

FIG. 7 shows another form of geometry for retaining the insulating material within the channels, in which pointed projections 114, rather than tabs or slits, extend

inwardly from the walls of the channels to engage the insulating material 110. It will be understood that the particular retaining geometry may vary from the examples which are shown in the figures, and may take the form of ridges, indentations, projections, constrictions, scorings or any other configuration which is suitable for engaging and holding the insulating material. Moreover, the retaining geometry may vary in configuration with the type of insulating material being used, and in some embodiments may be absent altogether.

The insulating material 110 itself may be of any suitable type, with a plastic material having good insulating qualities being eminently suitable for this purpose. Resilient, foamed plastic materials are particularly suitable for use as the insulating material, in that the cellular structure allows for a comparatively large degree of compression/expansion in order to accommodate the different expansion rates. Suitable examples of insulating materials include polyurethane foam, which is generally UV resistant, highly stable, and acid resistant. Polyethylene foam may also be used, which has the advantage of relative economy, although this should generally be provided with a "skin" on the exposed side to minimize deterioration. Moreover, the insulating material may contain a fiber material for enhanced stability and durability. Other suitable insulating materials will occur to those skilled in the art, and are also within the scope of the invention.

In some embodiments the insulating material may be formed as a continuous "cap" which fills and spans two or more channels, although in such instances the different expansion rates of the materials may become an even more significant factor, tending to cause the insulation to separate from the web. Also, in those embodiments where it is desired to maintain fluid communication between the inter-pane airspace and the interior of the spacer via slits in the channels, the insulating material may be formed of an open-cell foam material which is capable of "breathing"; in other embodiments, where the slits are absent or are blocked by the insulating material, the air flow can be maintained through the relatively porous upper seam 50.

d. Two-Piece Construction

FIG. 8 shows a tubular spacer bar 120 in accordance with the present invention, having a construction which differs from that described above in that this is a two-piece structure with a somewhat "U" shaped lower channel member 122 and a "clip-on" upper web member 124.

As can be seen, the overall configuration of the lower channel member 122 is somewhat similar to the lower part of the spacer which was described above with reference to FIG. 2, in that this has a bottom web 126 and first and second side webs 128, 130. The side webs also preferably include upper and lower contact lines 132a, 132b and 134a, 134b, as well as horizontally extending folds 136a, 136b for increasing of the length of the conductive path across the bottom of the spacer.

In the embodiment which is shown in FIG. 8, however, first and second flanges are formed inboard of the upper contact lines 132a, 132b, and these extend downwardly and inwardly and then back upwardly and inwardly to define "V" shape receiving channels 140a and 140b. Furthermore, the terminal edges of the flanges are provided with reverse bends so as to form a small locking lips 142a, 142b along the inward edges of the receiving channels.

The outer edges 144a, 144b of the upper web member 124, in turn, are bent downwardly and inwardly so as to form first and second downwardly projecting locing flanges 146a, 146b. As can be seen in FIG. 8, the flanges 146a, 146b are configured to extend roughly parallel to the sheet metal which forms the outer walls of the receiving channels 140a, 140b, and extend downwardly from the top web by a distance which is roughly equal to the depth of the receiving channels.

To assemble the spacer 120, the interior of the "U" shaped lower channel member 122 is filled with the desired amount of desiccant material 148, and the upper web member 124 is placed across the top opening of the channel member with the downwardly projecting edge flanges 146a, 146b positioned in vertical register with receiving channels 140a, 140b. The web member is then pressed downwardly against the channel member so that the edge flanges are forced into the receiving channels. As this is done, the lower, somewhat inwardly-angled edges of flanges 146a, 146b ride over the

lips 142a, 142b of the receiving channels, so that the sides of the channels are spread apart resiliently to accept entry of the flanges.

After the lower edges of the flanges 146a, 146b have been forced downwardly past the edges of lips 142a, 142b, the flanges and the sides of the receiving channels spring back to their original configurations, so that the locking lips move inwardly to a position above the lower edges of the flanges (i.e., to the position shown in FIG. 8), thereby capturing the flanges and retaining them against being withdrawn from the receiving channels 140a, 140b. Thus, once installed, the web member 124 is more or less permanently mounted to the "U" shaped channel member 122.

As is shown in FIG. 10, in some embodiments the lower edges of flanges 146a, 146b may also be provided with reverse bends, which form inwardly and upwardly projecting secondary locking lips 150. Thus, as the edge flanges are pressed home in the receiving channels, the primary locking lips 142 spring or "snap" back so as to move into abutting opposition with the secondary locking lips 150, providing very strong resistance against separation of the web and channel members once mated.

A particular advantage of the two-piece "snap together" construction which is shown in FIGS. 8-10 is that the "broken" attachment points along the two edges of the spacer create discontinuities which further reduce conductive heat transfer across the upper web of the spacer. Furthermore, the "breaks" at the edge joints permit air/gasses to pass between the interpane space and the interior of the spacer, even in embodiments in which the upper web itself lacks any slits or other perforations.

Still further, this arrangement permits the upper web to be formed of a separate material, such as stainless steel, which exhibits a lower rate of thermal heat transmission than most metals but which is also more costly, while allowing the remainder of the assembly (i.e., the "U" shaped lower channel member) to be formed of a less expensive material such as ordinary steel or aluminum. Similarly, the separate upper web member can be painted, coated or otherwise treated for reduced thermal gain or other enhanced characteristics, without having to treat the entire assembly.

Moreover, the snap-together construction allows upper web members of different types to be interchangeably mounted on a common form of lower channel, thereby allowing for simplified and more economical manufacture of different models of spacer

bar. For example, as can be seen in FIG. 8, the upper web member 124 may be formed with a series of parallel corrugations 70, with or without embedded insulating strips 90, similar to the embodiments which have been described above. Alternatively, other forms of upper web members can be mounted to an identical channel member in the same manner. For example, FIG. 9 shows a spacer 120' which the upper web member 124', rather than being corrugated, is a generally planar member having several rows of staggered slits 152. Although lacking the corrugations, the slits 152 are formed in essentially the same manner as described above (except that the tab portions 154 are bent downwardly rather than upwardly), so that the longitudinal edges of each slit are separated by a narrow air gap 156. Also, as was described above, first and second breaks/tears 158a, 158b extend laterally from the ends of each slit towards the next row of slits, so that thermal energy must follow an elongate, circuitous path in order to travel from one glass pane to the other, as indicated by arrow 160.

e. Corner bending

As noted above, a consistent problem with prior forms of spacer bars has been the tendency to crack or separate at the seams when bent to form a corner. In general, this caused by aluminum or other material being pulled or stretched through an excessive distance along the outer radius of the corner as the bend is being formed, which is due in turn to the height of the spacer tubing (i.e., the distance between the walls that are facing towards and away from the interpane space). However, it will be understood that the spacer bar must have some degree of height at the corners, or else it will be an insufficient sidewall areas for engaging and forming a seal with the glass panes. The present invention overcomes this problem.

As can be seen in FIG. 11 the tubular spacer frame bar 200 of the present invention is bent to form a corner of the spacer frame by applying pressure in the direction indicated by arrow 202 while bending the two legs 204a and 204b to a right angle or other angular orientation. This can be done using any of variety of conventional bending tools that are available and are well-known to those skilled in the art.

Unlike conventional spacer frame tubing, the corrugations 206 in the side webs 208a, 208b collapse as the spacer frame bar is bent, reducing the height between the

upper and lower webs 210, 212. As a result, the distance through which the material of the bar is stretched at the outside radius 214 of the corner is reduced sufficiently that cracking of the material and separation of the seams is avoided.

FIG. 12 presents a cross-sectional view of the spacer frame bar 200, which is simplified somewhat in that the bar is shown with a flat upper web 210. It will be understood that the upper web be flat as shown, or may have corrugations and/or seams as shown in FIGS. 2 and 8, or may have any other suitable configuration; moreover, it will be understood that the upper web will in most embodiments be provided with perforations, slits or other openings for passage of moisture/air to the dessicant material which is enclosed therein. Similarily, the lower web 212 is shown with an overlapping center seam 216, but will be understood that the lower web may have any suitable configuration; the reduced stretching of the lower web which is provided by the present invention is particularly advantageous for use with spacer frame bar having a welded (e.g., laser welded) seam in the lower web, since welded seams are particularly susceptible to separation when over-stretched.

The two side webs 208a, 208b, in turn, are substantially similar to those as shown above, and have upper portions that form contact areas 218a, 218b having concave, longitudinally extending recesses 220a, 220b bordered by upper and lower contact ridges 222a, 222b and 224a, 224b. The lower portions of the side webs, in turn, include the corrugated areas 206a, 206b. In the illustrated embodiment, each corrugated area includes two longitudinally extending channels 226a, 226b and 228a, 228b, alternating with ridges 230a, 230b and 232a, 232b. This provides the desired degree of compression and is easily roll-formed, however, it will be understood that a lesser or greater number of channels and grooves may be employed in some embodiments; moreover, in addition to providing the collapsing action the corrugated areas increase the length of the thermal path between the lower and upper webs of the spacer bar, and their number and configuration may be varied on the basis of this factor as well.

As can be seen, each of the channels/ridges of the corrugated areas have generally parallel upper and lower walls 234 so as to define a series of spaced, vertical gaps 236. Moreover, walls 234 are disposed in parallel, face-to-face relationship on opposite sides of each gap. As will be described in greater detail below, the gaps from the collapsible

areas that allow the height of the side webs to collapse as the tubing is bent, and in cooperation with the walls 234 control the direction and extent of the deformation.

FIG. 12 shows the tubular spacer bar in its initial configuration prior to bending, having its full height "h1". FIG. 13, in turn, shows the spacer bar in its collapsed configuration in the area where it has been bent from the corner of the spacer frame. As can be seen,. the outwardly directed pressure at the corner (see arrow 202) and the action of bending the two legs 204a, 204b towards one another cooperate to force the upper and lower webs of the tubular bar towards one another, as indicated by arrow 240a, 240b. In response, the gaps 236 formed by the channels and ridges of the corrugations collapse and disappear, until the opposing wall portions 234 move into abutment with one another. This results in a reduced height "h2" at the apex of the bend. As a result, the metal of the lower web 212 is stretched through a reduced distance (as opposed to bending a bar having a constant height), thereby avoiding cracking of the material and at the same time preserving the integrity of the seam 216.

The manner in which the walls 234 move into abutment as the gaps close maintains the amount of collapse and deformation within predetermined limits. Moreover, the configuration of the wall portions 234, extending generally parallel to the upper and lower webs 210, 212, helps ensure that the corrugations collapse evenly without buckling to one side or the other. As a result, distortion of the bar's profile is kept within acceptable limits so that the ability to form a seal with the panes is not compromised. For an example, as can be seen in FIG. 13, the contact areas 218a, 218b remain substantially enact and the contact ridges 220a, 220b and 224a, 224b are not creased or peaked outside of the plane of panes; at the same time the outer edges of the ridges 230a, 230b and 232a, 232b remain spaced inwardly by distance "d" similar to their original configuration so as to avoid creating additional contact points against the glass. Also, a hollow passage 242 is maintained through the interior of the bar, between the upper portions of the two side webs; this facilities filling the interior of the tubing with dessicant after the bar has been bent, if desired.

The configuration of the corrugations of the preferred embodiment which is illustrated therefore provides several significant advantages. It will be understood, however, that in some embodiments corrugations having somewhat different

configurations may be employed. However, in some embodiments the tubing may be configured to collapse more completely than shown in FIG. 13.

It is to be recognized that various alterations, modifications, and\or additions may be introduced into the constructions and arrangements of parts described above without departing from the spirit or ambit of the present invention.